Am. J. Trop. Med. Hyg., 62(2)S, 2000, pp. 88–99

THE EPIDEMIOLOGY OF SCHISTOSOMIASIS IN EGYPT: SUMMARY FINDINGS IN NINE GOVERNORATES

TAHA EL-KHOBY, NABIL GALAL, ALAN FENWICK, RASHIDA BARAKAT, AHMED EL-HAWEY, ZOHEIR NOOMAN, MUSTAFA HABIB, FARID ABDEL-WAHAB, NABIL S. GABR, HAMMAM M. HAMMAM, MOHAMED H. HUSSEIN, NABIEL N. H. MIKHAIL, BARNETT L. CLINE, AND G. THOMAS STRICKLAND

Schistosomiasis Research Project, The Egyptian Organization for Biological and Vaccine Production, Agouza, Egypt; Department of Parasitology, High Institute of Public Health, Alexandria, Egypt; Department of Tropical Medicine, Faculty of Medicine, Al Azhar University, Cairo, Egypt; Suez Canal University Faculty of Medicine, Ismailia, Egypt; Center for Applied Research, Warac, Egypt; Department of Tropical Medicine and Department of Community Medicine, Faculty of Medicine, University of Cairo, Cairo, Egypt; Department of Parasitology, Faculty of Medicine, Minya University, Minya, Egypt; Department of Community Medicine, Faculty of Medicine, Assiut University, Assuit, Egypt; Center for International Health and Tropical Medicine, Tulane University School of Public Health and Tropical Medicine, New Orleans, Louisiana; International Health Program, Department of Epidemiology and Preventive Medicine, School of Medicine, University of Maryland at Baltimore, Baltimore, Maryland

Abstract. Health questionnaires and parasitologic examinations of urine and stool were evaluated from a stratified random sample of 89,180 individuals from 17,172 households in 251 rural communities in 9 governorates of Egypt to investigate the prevalence of, risk factors for, and changing pattern of infection with *Schistosoma* sp. in Egypt. A subset, every fifth household, or 18,600 subjects, had physical and ultrasound examinations to investigate the prevalence of and risk factors for morbidity. Prevalence of *S. haematobium* in 4 governorates in Upper Egypt in which it is endemic ranged from 4.8% to 13.7% and averaged 7.8%. The geometric mean egg count (GMEC) ranged from 7.0 to 10.0 ova/10 ml of urine and averaged 8.1. Age stratified prevalence of infection peaked at 15.7% in the 10–14-year-old age group and decreased to 3.5–5.5% in all groups more than 25 years of age. Age-stratified intensity of infection peaked at approximately 10.0 ova/10 ml of urine in the 5–14-year-old age groups and was about half that in all groups more than 25 years of age. Males had higher infection rates and ova counts than females in all age groups. *Schistosoma mansoni* was rare in Upper Egypt, being consequential in only Fayoum, which had a prevalence of 4.3% and an average intensity of infection of 44.0 ova/g of stool. Risk factors for *S. haematobium* infection were male gender, an age <21 years old, living in smaller communities, exposures to canal water; a history of, or treatment for, schistosomiasis, a history of burning micturition or blood in the urine, and reagent strip-detected hematuria or proteinuria. The more severe grades (II and III) of ultrasonography-detected periportal fibrosis (PPF) were rare (15 of 906) in these schistosomiasis haematobia-endemic governorates. Risk factors for morbidity (ultrasonography-detected urinary bladder wall lesions and/or obstructive uropathy) were similar to those for infection, with the exception that risk progressively increased with age. Subjects with active *S. haematobium* infections were 3 times as likely as those without active *S. haematobium* infections to have urinary tract morbidity. The prevalence of *S. mansoni* in 5 governorates in Lower Egypt, where it is endemic, ranged from 17.5% to 42.9% and averaged 36.4%. The GMEC ranged from 62.6 to 93.3 eggs/g of stool and averaged 81.3. Age-stratified prevalence of infection peaked at 48.3% in the 15–19-year-old age group, but averaged 35–45% in all groups more than 10 years of age. The intensity of infection was highest in the 10–14-year-old age group, and showed a range of 70–85 eggs/g of stool in those ≥ 5 years of age. Males had higher infection rates and ova counts than females in all age groups. *Schistosoma haematobium* was rare in these governorates; Ismailia (1.8%) had the highest infection rate. Risk factors for *S. mansoni* were male gender, an age >10 years old, living in smaller communities, exposures to canal water, a history of, or treatment for, schistosomiasis or blood in the stool, detection of splenomegaly by either physical examination or ultrasonography, and ultrasonography-detected PPF. The more severe grades (II and III) accounted for 463 (13.3%) of the 3,494 having ultrasonography-detected PPF. Risk factors for morbidity (ultrasonography-detected PPF) were similar to those for infection except that inhabitants of smaller communities were not at increased risk. Active *S. mansoni* infection increased the odds ratio (OR) of having PPF by 1.37. In comparison with others with normal-size livers, subjects having hepatic enlargement in either the midclavicular line or the midsternal line detected by physical examination or ultrasonography had a reduced risk (ORs = 0.64–0.72) of PPF. The prevalences of lesions detected by ultrasonography were 23.7% for enlargement of right lobe of the liver, 11.3% for enlargement of left hepatic lobe, 20.6% for splenomegaly, and 50.3% for PPF. *Schistosoma mansoni* has almost totally replaced *S. haematobium* in Lower Egypt and is spreading into Fayoum in Upper Egypt. The prevalence of *S. mansoni* in the Nile Delta remains high with moderate average intensities of infection in rural communities. Hepatic morbidity was less than expected and, with the exception of splenomegaly, correlated poorly with active *S. mansoni* infections in individuals or in communities. The prevalence and intensity of infection with *S. haematobium* was low in endemic Upper Egypt governorates. The prevalence of bladder and upper urinary tract morbidity were low but correlated with active infection. Hepatomegaly, splenomegaly, and PPF were common findings in rural communities in Egypt. They occurred 1.5–3.5 times as frequently in areas endemic for schistosomiasis mansoni as in areas endemic for schistosomiasis haematobia, and were not specific for the latter, since these ultrasonography-detected lesions had no or marginal relationships with *S. haematobium* infection and morbidity.

Egypt is a cradle of civilization, but has been plagued by schistosomiasis since at least the Middle Kingdom period (1,500 BC).[1] The predominant species causing infection was *Schistosoma haematobium*, with hematuria being the most prominent symptom and chronic urinary tract lesions a major cause of morbidity. Theodor Bilharz discovered *Schistosoma* from human autopsy material in Cairo in 1851 and later described the relationship of the parasite to pathologic lesions. Leiper, working from about 1910 to 1918, showed there were 2 species of *Schistosoma* in Egypt, a urinary form

TABLE 1

Subjects investigated and prevalence and intensity of infection with *Schistosoma mansoni* and *S. haematobium* in the 9 governorates in the survey

Governorate	Sample size	*S. mansoni*		*S. haematobium*	
		Prevalence (%)	Intensity of infection (ova/g of stool)	Prevalence (%)	Intensity of infection (ova/10 ml of urine)
Qena	17,822	0.44	47.71	4.78	7.04
Assiut	14,204	0.42	48.94	5.21	6.63
Minya	16,433	1.04	83.10	8.89	8.47
Fayoum	7,710	4.33	44.00	13.69	9.95
Qalubia	8,555	17.47	62.58	0.08	1.53
Manofia	10,899	28.49	81.28	0.44	5.50
Gharbia	14,344	37.70	78.93	0.26	2.06
Kafr-El-Sheikh	18,186	39.17	72.94	0.45	2.54
Ismailia	12,754	42.90	93.33	1.80	3.55

and an intestinal form, and that they were transmitted by snails of 2 genera. Prior to 1935, the only publications on the prevalence of schistosomiasis and morbidity it caused in Egypt were based upon data from outpatient and hospital inpatient records and pathologic reports, with the most extensive one published by Khalil.[2]

Over the past 50 or 60 years, schistosomiasis mansoni, which causes gastrointestinal and hepatic manifestations, has been increasing, particularly in the Nile Delta. The prevalence of schistosomal infection increased in Upper Egypt, along the Nile River south of Assiut, in association with perennial irrigation for agricultural purposes during the past 70 or 80 years.[1] In addition, there has been a striking change in the geographic distribution of the 2 species of *Schistosoma* since the construction of the Aswan High Dam 25–30 years ago.[3–5] This change was believed to be caused by less silt and variability in velocity and volume of water flow since construction of the dam and has resulted in an increase in *S. mansoni* and concomitant decrease in *S. haematobium* prevalence spreading from the Nile delta into Upper Egypt. This reversal in human infection rates apparently followed a similar change in abundance of snail vectors for the 2 parasites.

Under sponsorship of the Egyptian Ministry of Health and the United States Agency for International Development (USAID), the Schistosomiasis Research Project supported the investigation of prevalence and intensity of infection with *Schistosoma* sp., the prevalence and magnitude of morbidity caused by schistosomiasis, the changing pattern of distribution of *S. mansoni* and *S. haematobium*, and the determinants of infection and morbidity in a random sample of the rural inhabitants of 9 governorates in the country selected as representative of each area (Upper and Lower Egypt) and of governorates with both high and low infection rates (Figure 1 of Hussein and others[6]). This is the second national house-to-house survey for schistosomiasis in Egypt; J. A. Scott's investigation was conducted 60 years previously.[6] Reported herein is a summarized version of the results from all 9 governorates.

SUBJECTS AND METHODS

The data was stratified into 2 groups: 5 governorates in Lower Egypt (Kafr El Sheik, Gharbia, Menofia, Qalubia, and Ismailia) almost exclusively endemic for *S. mansoni* and 4 governorates in Upper Egypt (Fayoum, Minya, Assiut, and Qena) primarily endemic for *S. haematobium* (Figure 1 of Hussein and others[6]). Separation by geographic areas proved useful and credible since, except for the Fayoum, which had a 4.3% infection rate with *S. mansoni*, the amount of infection with the minor *Schistosoma* species in the other governorates was trivial (<2%, Table 1).

The sample size, selected by multistage stratified random sampling, was calculated to detect a prevalence of *Schistosoma* sp. as low as 5% in villages or ezbas (satellite group of dwellings) with an 80% precision and 90% confidence level.[6] The findings are considered representative of the rural areas of the 9 governorates. The total sampled population was 120,907, but data on most variables were available on only 89,180 individuals: 49,950 in the Lower Egypt sample and another 39,230 from Upper Egypt. The mean number of each governorate was 9,990 subjects and ranged from 7,710 in the Fayoum to 18,186 in Kafr El Sheik (Table 1).

Randomizing took place at the village/ezba and household levels, but the total household was included in the study sample. A subsample of all inhabitants more than 5 years of age of every fifth household, i.e., approximately 18,600 subjects, were subjected to clinical and ultrasound assessment of morbidity that might be due to schistosomiasis.

The interview technique for collecting vital environmental, sociodemographic, and medical data has been described in detail.[6] Quantitative microscopic counting of *Schistosoma* ova in stool using a modified Kato technique and in urine using the Nucleopore (Pleasanton, CA) filter technique were performed as described.[8] Physical examination and abdominal ultrasonography were performed by trained physicians as described.[9] Children less than 5 years of age were excluded from physical and ultrasonographic examinations by protocol, but some were examined and these results are included.

Complete data were not available on all variables. These omissions are described in the papers covering the 9 governorates.[10–18] All data were transferred from the data collection forms to standard precoded sheets for computer entry using Epi-Info 5.01b (Centers for Disease Control and Prevention, Atlanta, GA). Data were verified by the Core Team prior to analysis.[7] Survey Data Analysis (SUDAAN) software was used to calculate *Schistosoma* prevalence and geometric mean egg count (GMEC) in its entirety and stratified by community, gender, and age as described.[6] Further anal-

TABLE 2

Odds ratio and 95% confidence intervals for risk factors for infection with *Schistosoma haematobium* in Fayoum, Minya, Assiut, and Qena Governorates*

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence intervals
Demographics				
Age groups (years)				
0–10	13,175	1,009 (7.7)		
11–20	9,378	1,355 (14.4)	2.04	1.87–2.22
21–35	7,839	410 (5.2)	0.67	0.59–0.75
36–55	5,934	184 (3.1)	0.39	0.33–0.45
>55	2,904	96 (3.3)	0.41	0.33–0.51
Gender				
Female	20,292	1,134 (5.6)		
Male	18,939	1,920 (10.1)	1.91	1.77–2.06
Domicile				
Village (≥500 houses)	12,536	1,058 (8.9)		
Ezba (<500 houses)	26,694	2,156 (8.1)	1.14	1.05–1.23
Exposure to canal water				
Bathing (males)				
No	11,854	1,058 (8.9)		
Yes	5,274	759 (14.4)	1.72	1.55–1.89
Washing (females)				
No	14,849	707 (4.8)		
Yes	4,322	387 (9.0)	1.97	1.73–2.24
Playing (children <15 years old)				
No	12,144	1,064 (8.8)		
Yes	3,292	557 (16.9)	2.12	1.90–2.37
Clinical findings				
History of schistosomiasis				
No	24,702	1,670 (6.8)		
Yes	6,929	843 (12.2)	1.91	1.75–2.09
Prior treatment of schistosomiasis				
No	28,188	2,009 (7.1)		
Yes	6,794	821 (12.1)	1.79	1.64–1.95
History of burning micturition				
No	4,165	281 (6.7)		
Yes (total)	2,045	205 (10.0)	1.54	1.28–1.86
<15 years	597	104 (17.4)	2.16	1.67–2.81
≥15 years	1,448	101 (7.0)	1.54	1.15–2.04
History of blood in urine				
No	5,190	302 (5.8)		
Yes	1,022	186 (18.2)	3.60	2.96–4.38
<15 years	442	121 (27.4)	4.60	3.54–5.97
≥15 years	580	65 (11.2)	2.67	1.96–3.65
Hepatomegaly in MCL (by PE)				
No	4,387	317 (7.2)		
Yes	500	40 (8.0)	1.12	0.79–1.57
<15 years	187	23 (12.3)	1.32	0.83–2.09
≥15 years	313	17 (5.4)	1.03	0.61–1.74
Splenomegaly (by PE)				
No	5,927	465 (7.8)		
Yes	295	23 (7.8)	0.99	0.64–1.54
<15 years	68	13 (19.1)	1.98	1.07–3.67
≥15 years	227	10 (4.4)	0.77	0.40–1.47
Laboratory findings				
Hematuria				
No	32,097	1,356 (4.2)		
Yes	6,812	1,671 (24.5)	7.37	6.82–7.96
<15 years	2,622	995 (37.9)	12.44	11.15–13.89
≥15 years	4,190	676 (16.1)	4.82	4.31–5.40

TABLE 2
Continued

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence intervals
Proteinuria				
No	37,875	2,608 (6.8)		
Yes	1,032	419 (40.6)	9.24	8.11–10.53
<15 years	492	291 (59.1)	16.03	13.28–19.34
≥15 years	540	128 (23.7)	5.07	4.13–6.24
Ultrasonography				
Hepatomegaly in MCL				
No	4,136	299 (7.2)		
Yes	587	47 (8.0)	1.12	0.81–1.54
<15 years	231	33 (14.3)	1.61	1.08–2.40
≥15 years	356	14 (3.9)	0.70	0.40–1.23
Hepatomegaly in MSL				
No	4,315	317 (7.3)		
Yes	407	29 (7.1)	0.97	0.65–1.44
<15 years	151	18 (11.9)	1.25	0.75–2.09
≥15 years	256	11 (4.3)	0.78	0.42–1.47
Splenomegaly				
No	5,317	393 (7.4)		
Yes	824	76 (9.2)	1.27	0.98–1.65
<15 years	242	29 (12.0)	1.16	0.77–1.75
≥15 years	582	47 (8.1)	1.71	1.21–2.40
Periportal fibrosis				
No	5,265	391 (7.4)		
Yes (≥3 mm)	906	88 (9.7)	1.34	1.05–1.71
<15 years	299	36 (12.0)	1.15	0.79–1.67
≥15 years	607	52 (8.6)	1.82	1.31–2.53
Grade I (3–<5 mm)	891	84 (9.4)	1.30	1.01–1.66
Grade II (5–<7 mm)	6	3 (50.0)	12.47	2.51–61.97
Grade III (≥7 mm)	9	1 (11.1)	1.56	0.19–12.49
Bladder wall lesions				
No	6,074	440 (7.2)		
Yes	122	40 (32.8)	6.25	4.23–9.23
<15 years	76	31 (40.8)	6.25	3.88–10.05
≥15 years	46	9 (19.6)	4.36	2.07–9.16
Obstructive uropathy				
No	6,068	464 (7.6)		
Yes	189	22 (11.6)	1.59	1.01–2.51
<15 years	30	9 (30.0)	3.62	1.64–7.97
≥15 years	159	13 (8.2)	1.56	0.87–2.80

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

ysis was performed after transformation to SPSS/PC + 4.01 (SPSS, Inc., Chicago, IL). This software was used to calculate odds ratios (ORs) and 95% confidence intervals (CIs). The community burden of *S. mansoni* was calculated by using the GMEC log(x + 1). The product moment correlation coefficient (r) and its statistical significance (*P*) were used for testing the association of morbidity variables of interest, e.g., splenomegaly by ultrasonography, with the community burden of schistosomiasis. Graphic presentations were prepared using Harvard Graphics 3.0 (Software Publishing Corp., Mountain View, CA).

RESULTS

Schistosomiasis haematobia. The prevalence of *S. haematobium* in the 4 governorates where it was endemic averaged 7.8% and ranged from 4.8% in Qena to 13.7% in Fayoum (Table 1). The average intensity of infection was a GMEC of 8.1 eggs/10 ml of urine and ranged from 7.0 in Qena to 10.0 in Fayoum. Age-adjusted prevalence of infection peaked at 15.7% in the 10–14-year-old group and decreased to 3.5–5.5% in all groups more than 25 years of age (Figure 1). The 11–20-year-old age group was twice as likely to have *S. haematobium* infections as the <10-year-old age group (Table 2); in comparison with the <10-year-old age group those more than 36 years of age had an OR of 0.4 of having an infection. Males had a higher prevalence of infection than females in all age groups (Figure 1). Males were 1.9 times as likely to be infected as females (Table 2). The intensity of infection was highest, with a GMEC of slightly more than 10 ova/10 ml of urine, in the 5–14-year-old age groups. The GMECs in all groups more than 25 years of age were about half of this value. Those living in ezbas were slightly more likely (OR = 1.1) to be infected than subjects

TABLE 3

Odds ratio and 95% confidence intervals for risk factors for urinary tract morbidity (obstructive uropathy and/or bladder wall lesion) with *Schistosoma haematobium* in Fayoum, Minya, Assiut, and Qena Governorates*

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence intervals
Demographics				
Age groups (years)				
0–10	2,443	79 (3.2)		
11–20	1,805	94 (5.2)	1.64	1.21–2.23
21–35	1,498	64 (4.3)	1.34	0.95–1.87
36–55	1,170	74 (6.3)	2.02	1.46–2.80
>55	570	46 (8.1)	2.63	1.80–3.82
Gender				
Female	3,892	91 (2.3)		
Male	3,594	266 (7.4)	3.34	2.62–4.25
Domicile				
Village (≥500 houses)	2,334	86 (3.7)		
Ezba (<500 houses)	5,152	271 (5.3)	1.45	1.13–1.86
Exposure to canal water				
Bathing (males)				
No	2,131	132 (6.2)		
Yes	1,097	116 (10.6)	1.79	1.38–2.32
Washing (females)				
No	2,725	55 (2.0)		
Yes	905	32 (3.5)	1.78	1.14–2.77
Playing (children <15 years old)				
No	2,106	65 (3.1)		
Yes	687	53 (7.7)	2.62	1.81–3.81
Parasitologic findings				
S. haematobium infection				
No	5,660	228 (4.0)		
Yes	479	55 (11.5)	3.09	2.27–4.22
<20 ova/10 ml of urine	360	41 (11.4)	3.06	2.16–4.35
≥20 ova/10 ml of urine	119	14 (11.8)	3.18	1.79–5.63
Clinical findings				
History of schistosomiasis				
No	4,554	180 (4.0)		
Yes	1,400	108 (7.7)	2.03	1.59–2.60
Prior treatment of schistosomiasis				
No	5,274	220 (4.2)		
Yes	1,370	107 (7.8)	1.95	1.53–2.47
History of burning micturition				
No	4,821	159 (3.3)		
Yes (total)	2,331	179 (7.7)	2.44	1.96–3.04
<15 years	665	54 (8.1)	3.03	2.10–4.37
≥15 years	1,666	125 (7.5)	2.07	1.57–2.74
History of blood in urine				
No	5,963	219 (3.7)		
Yes	1,185	120 (10.1)	2.96	2.34–3.73
<15 years	493	57 (11.6)	5.11	3.53–7.39
≥15 years	692	63 (9.1)	2.08	1.54–2.83
Hepatomegaly in MCL (by PE)				
No	5,148	262 (5.1)		
Yes	577	31 (5.4)	1.06	0.72–1.55
<15 years	223	10 (4.5)	1.00	0.51–1.94
≥15 years	354	21 (5.9)	1.06	0.67–1.70
Splenomegaly (by PE)				
No	6,847	311 (4.5)		
Yes	324	29 (9.0)	2.07	1.39–3.08
<15 years	75	8 (10.7)	3.03	1.42–6.45
≥15 years	249	21 (8.4)	1.70	1.06–2.72

TABLE 3
Continued

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence intervals
Laboratory findings				
Hematuria				
No	5,092	186 (3.7)		
Yes	1,107	107 (9.7)	2.82	2.20–3.61
<15 years	393	36 (9.2)	3.38	2.21–5.15
≥15 years	714	71 (9.9)	2.49	1.84–3.38
Proteinuria				
No	6,036	271 (4.5)		
Yes	164	22 (13.4)	3.30	2.07–5.25
<15 years	73	9 (12.3)	3.78	1.82–7.82
≥15 years	91	13 (14.3)	3.07	1.67–5.62
Ultrasonography				
Hepatomegaly in MCL				
No	5,079	271 (5.3)		
Yes	692	27 (3.9)	0.72	0.48–1.08
<15 years	276	13 (4.7)	1.06	0.58–1.91
≥15 years	416	14 (3.4)	0.54	0.31–0.94
Hepatomegaly in MSL				
No	5,300	277 (5.2)		
Yes	471	21 (4.5)	0.85	0.54–1.33
<15 years	177	10 (5.6)	1.30	0.67–2.53
≥15 years	294	11 (3.7)	0.62	0.33–1.15
Splenomegaly				
No	6,447	273 (4.2)		
Yes	948	80 (8.4)	2.08	1.61–2.70
<15 years	288	25 (8.7)	2.61	1.65–4.11
≥15 years	660	55 (8.3)	1.79	1.31–2.46
Periportal fibrosis				
No	6,338	260 (4.1)		
Yes (≥3 mm)	1,089	92 (8.4)	2.16	1.69–2.76
<15 years	366	26 (7.1)	2.07	1.33–3.23
≥15 years	723	66 (9.1)	2.11	1.56–2.85
Grade I (3–<5 mm)	1,073	92 (8.6)	2.19	1.71–2.81
Grade II (5–<7 mm)	6	0 (0.0)		
Grade III (≥7 mm)	10	0 (0.0)		

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

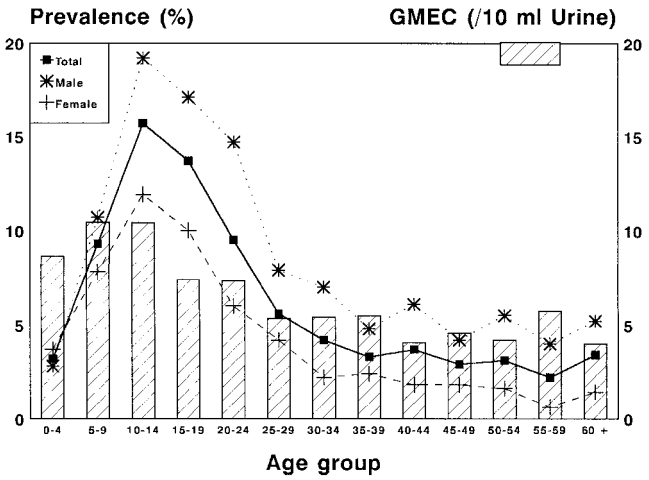

FIGURE 1. Age- and gender-adjusted prevalence and intensity of *Schistosoma haematobium* infection in 39,230 randomly selected subjects in 4 governorates in Upper Egypt endemic for schistosomiasis haematobia. GMEC = geometric mean egg count.

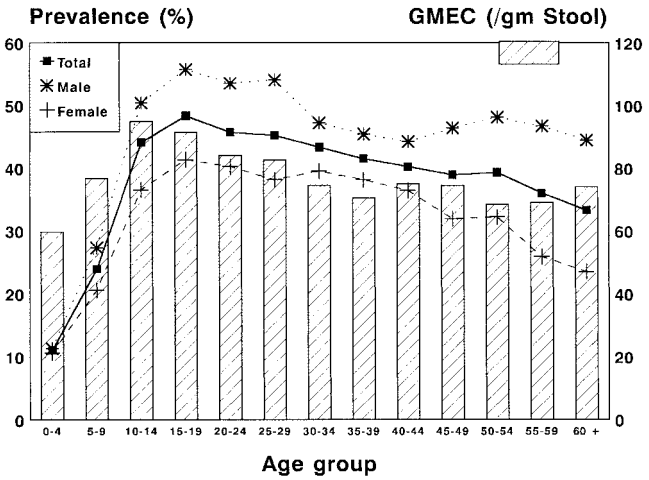

FIGURE 2. Age- and gender-adjusted prevalence and intensity of *Schistosoma mansoni* infection in 49,950 randomly selected subjects in 5 governorates in Lower Egypt endemic for schistosomiasis mansoni. GMEC = geometric mean egg count.

TABLE 4

Odds ratio and 95% confidence intervals for risk factors for infection with *Schistosoma mansoni* in Kafr-El-Sheikh, Gharbia, Menofia, Qalubia, and Ismailia Governorates*

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence intervals
Demographics				
Age groups (years)				
0–10	15,191	3,179 (20.9)		
11–20	12,739	5,941 (46.6)	3.30	3.13–3.48
21–35	10,899	4,812 (44.2)	2.99	2.83–3.18
36–55	7,712	3,037 (39.4)	2.45	2.31–2.61
>55	3,277	1,117 (34.1)	1.95	1.80–2.12
Gender				
Female	25,582	8,020 (31.4)		
Male	24,240	10,069 (41.5)	1.56	1.50–1.61
Domicile				
Village (≥500 houses)	15,675	4,142 (26.4)		
Ezba (<500 houses)	34,277	14,042 (41.0)	1.93	1.85–2.01
Exposure to canal water				
Bathing (males)				
No	9,940	2,799 (28.2)		
Yes	12,039	6,343 (52.7)	2.84	2.67–3.01
Washing (females)				
No	11,420	2,537 (22.2)		
Yes	12,986	5,144 (39.6)	2.30	2.17–2.43
Playing (children <15 years old)				
No	10,732	2,015 (18.8)		
Yes	8,931	3,483 (39.0)	2.77	2.59–2.95
Clinical findings				
History of schistosomiasis				
No	26,790	8,483 (31.7)		
Yes	14,375	6,162 (42.9)	1.62	1.55–1.69
Prior treatment of schistosomiasis				
No	31,774	10,598 (33.4)		
Yes	14,231	6,045 (42.5)	1.48	1.42–1.54
History of blood in stools				
No	11,162	4,158 (37.3)		
Yes (total)	1,231	716 (58.2)	2.34	2.08–2.64
<15 years	415	246 (59.3)	3.07	2.50–3.77
≥15 years	816	470 (57.6)	1.91	1.65–2.21
History of abdominal pain				
No	9,074	3,583 (39.5)		
Yes	3,295	1,278 (38.8)	0.97	0.89–1.05
<15 years	1,295	465 (35.9)	1.10	0.97–1.26
≥15 years	2,000	813 (40.7)	0.85	0.77–0.95
Hepatomegaly in MCL (by PE)				
No	11,429	4,475 (39.2)		
Yes	1,758	753 (42.8)	1.16	1.05–1.29
<15 years	658	260 (39.6)	1.28	1.08–1.51
≥15 years	1,100	493 (44.8)	1.06	0.93–1.20
Splenomegaly (by PE)				
No	11,932	4,642 (38.9)		
Yes	467	232 (49.7)	1.55	1.29–1.87
<15 years	73	39 (53.4)	2.26	1.42–3.59
≥15 years	394	193 (49.0)	1.27	1.03–1.55
Ultrasonography				
Hepatomegaly in MCL				
No	5,322	1,692 (36.9)		
Yes	1,528	601 (39.3)	1.11	0.99–1.25
<15 years	655	228 (34.8)	1.24	1.03–1.49
≥15 years	873	373 (42.7)	1.05	0.90–1.22

TABLE 4
Continued

Risk factor	Total in group	Infected No. (%)	Odds ratio	Confidence intervals
Hepatomegaly in MSL				
No	6,112	2,254 (36.9)		
Yes	735	306 (41.6)	1.22	1.04–1.43
<15 years	327	125 (38.2)	1.42	1.12–1.81
≥15 years	408	181 (44.4)	1.12	0.91–1.38
Splenomegaly				
No	5,517	1,933 (35.0)		
Yes	1,453	675 (46.5)	1.61	1.43–1.81
<15 years	337	141 (41.8)	1.69	1.34–2.13
≥15 years	1,116	534 (47.8)	1.41	1.22–1.62
Periportal fibrosis				
No	3,447	1,164 (33.8)		
Yes (≥3 mm)	3,494	1,439 (41.2)	1.37	1.25–1.51
<15 years	1,028	358 (34.8)	1.28	1.09–1.51
≥15 years	2,466	1,081 (43.8)	1.23	1.08–1.40
Grade I (3–<5 mm)	3,031	1,216 (40.1)	1.31	1.19–1.45
Grade II (5–<7 mm)	378	179 (47.4)	1.76	1.42–2.18
Grade III (≥7 mm)	85	44 (51.8)	2.10	1.37–3.24

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

living in larger communities. A history of any of several types of exposures to canal water increased the ORs of having an *S. haematobium* infection. Other risk factors significantly associated with *S. haematobium* infection were a history of (OR = 1.9), or treatment for (OR = 1.8), schistosomiasis and a recent history of burning micturition (OR = 1.5) or blood in the urine (OR = 3.6).

Reagent strip-detected hematuria was present in 17.5% of the 39,909 having this test and markedly increased the OR of infection (OR = 7.3), particularly in children (OR = 12.4, Table 2). Only 2.7% of 38,907 subjects tested by this procedure had proteinuria, but it markedly increased the odds (OR = 9.2) of *S. haematobium* infection, particularly in children (OR = 16.0).

Hepatomegaly and splenomegaly detected by physical examination, except for splenomegaly in subjects <15 years of age (OR = 2.0), were not associated with *S. haematobium* infection (Table 2). Ultrasonography-detected hepatomegaly in the midclavicular line (MCL) was detected in 12.4% of the 4,723 subjects who had this evaluated; left hepatic lobe enlargement was detected less frequently. Splenomegaly was observed in 13.4% of the 6,141 evaluated for this finding. Periportal fibrosis (PPF) was present in 14.7% of the 6,171 subjects. All but 15 of the 906 with this lesion had minimal grade I changes. Ultrasonography-detected hepatomegaly in the MCL in children (OR = 1.6), splenomegaly in adults (OR = 1.7), and PPF in all ages (OR = 1.3) correlated slightly with *S. haematobium* infection.

Urinary bladder wall lesions were detected in only 122 (2.0%) of the 6,196 having ultrasonographic examinations of the bladder reported (Table 2). Bladder wall lesions were associated (OR = 6.3) with active *S. haematobium* infections. Ultrasonography-detected obstructive uropathy was present in 3.0% of the 6,257 subjects having renal examinations reported. Infections with *S. haematobium* were slightly more common (OR = 1.6) in those with urinary tract obstructive changes than in those without these lesions, particularly in children (OR = 3.6).

Urinary tract morbidity, defined as ultrasonography-detected urinary bladder wall lesions and/or obstructive uropathy, was present in 357 (4.8%) of the 7,486 having data that could be evaluated (Table 3). Risk factors for morbidity included increasing age (OR = 1.3–2.6), male gender (OR = 3.3), living in ezbas (OR = 1.5), males bathing in canal water (OR = 1.8), females washing dishes or clothing in canal water (OR = 1.8), and children swimming or playing in canal water (OR = 2.6), *S. haematobium* ova in the urine (OR = 3.1), a history of (OR = 2.1) or treatment for (OR = 2.0) schistosomiasis, and a history of burning micturition (OR = 2.4) or blood in the urine (OR = 3.0).

Both reagent strip-detected hematuria (OR = 2.8) and proteinuria (OR = 3.3) correlated with urinary tract morbidity (Table 3). Hepatomegaly detected by physical examination (OR = 1.1) was not associated with urinary tract morbidity; however, urinary tract morbidity was present twice as often (OR = 2.1) in subjects with enlarged spleens. Ultrasonography-detected hepatomegaly in the MCL (OR = 0.7) and hepatomegaly in the midsternal line (MSL; OR = 0.9) were not associated with urinary tract morbidity. However, urinary tract morbidity was present more frequently in subjects having ultrasonography-detected splenomegaly (OR = 2.1) and PPF (OR = 2.2) than in those not having these abnormalities.

Right hepatic lobe enlargement had a negative correlation in 2 governorates and a positive correlation in 2 governorates with the community burden of schistosomiasis haematobia. This relationship was of marginal statistical significance (r = 0.4, $P = 0.04$) only in Fayoum. Splenomegaly was not associated with the community burden of schistosomiasis haematobia in any governorate. Periportal fibrosis had a marginal positive association (r = 0.35, $P = 0.01$) in Qena with the community burden of schistosomiasis hae-

TABLE 5

Odds ratio and 95% confidence intervals for risk factors for morbidity (periportal fibrosis) with *Schistosoma mansoni* in Kafr-El-Sheikh, Gharbia, Menofia, Qalubia, and Ismailia Governorates*

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence intervals
Demographics				
Age groups (years)				
0–10	2,204	615 (27.9)		
11–20	2,015	1,057 (52.5)	2.85	2.51–3.24
21–35	1,732	1,070 (61.8)	4.18	3.65–4.78
36–55	1,245	751 (60.3)	3.93	3.39–4.55
>55	487	294 (60.4)	3.94	3.21–4.83
Gender				
Female	4,011	1,769 (44.1)		
Male	3,673	2,018 (54.9)	1.55	1.41–1.69
Domicile				
Village (≥500 houses)	2,536	1,286 (50.7)		
Ezba (<500 houses)	5,174	2,509 (48.5)	0.92	0.83–1.01
Exposure to canal water				
Bathing (males)				
No	1,604	745 (46.4)		
Yes	1,770	1,103 (62.3)	1.91	1.66–2.19
Washing (females)				
No	1,902	745 (46.4)		
Yes	1,948	1,031 (62.3)	2.06	1.81–2.35
Playing (children <15 years old)				
No	1,764	532 (30.2)		
Yes	1,232	506 (41.1)	1.61	1.39–1.88
Parasitologic findings				
S. mansoni infection				
No	4,338	2,055 (47.4)		
Yes	2,603	1,439 (55.3)	1.37	1.25–1.51
<100 ova/gram of stool	1,500	836 (55.7)	1.40	1.24–1.57
≥100 ova/gram of stool	1,103	603 (54.7)	1.34	1.17–1.53
Clinical findings				
History of schistosomiasis				
No	4,451	1,934 (43.5)		
Yes	2,144	1,341 (62.5)	2.17	1.96–2.42
Prior treatment of schistosomiasis				
No	5,025	2,173 (43.2)		
Yes	2,119	1,335 (63.0)	2.23	2.01–2.48
History of blood in stools				
No	6,732	3,259 (48.4)		
Yes	744	428 (57.5)	1.44	1.24–1.68
<15 years	233	85 (36.5)	1.11	0.84–1.46
≥15 years	511	343 (67.1)	1.42	1.17–1.73
History of abdominal pain				
No	5,547	2,749 (49.6)		
Yes	1,910	927 (48.5)	0.96	0.87–1.07
<15 years	693	224 (32.3)	0.89	0.74–1.06
≥15 years	1,217	703 (57.8)	0.89	0.78–1.01
Hepatomegaly in MCL (by PE)				
No	6,624	3,331 (50.3)		
Yes	869	367 (42.2)	0.72	0.63–0.83
<15 years	324	76 (23.5)	0.56	0.43–0.73
≥15 years	545	291 (53.4)	0.73	0.61–0.88
Splenomegaly (by PE)				
No	7,161	3,465 (48.4)		
Yes	315	221 (70.2)	2.51	1.96–3.21
<15 years	38	12 (31.6)	0.88	0.44–1.75
≥15 years	277	209 (75.5)	2.15	1.63–2.85

TABLE 5
Continued

Risk factor	Total in group	Morbidity No. (%)	Odds ratio	Confidence intervals
Ultrasonography				
Hepatomegaly in MCL				
No	5,754	2,986 (51.9)		
Yes	1,783	728 (40.8)	0.64	0.57–0.71
<15 years	766	173 (22.6)	0.48	0.39–0.58
≥15 years	1,017	555 (54.6)	0.75	0.65–0.86
Hepatomegaly in MSL				
No	6,679	3,361 (50.3)		
Yes	852	350 (41.1)	0.69	0.60–0.80
<15 years	366	91 (24.9)	0.60	0.47–0.77
≥15 years	486	259 (53.3)	0.74	0.61–0.89
Splenomegaly				
No	6,100	2,689 (44.1)		
Yes	1,581	1,091 (69.0)	2.82	2.51–3.18
<15 years	359	195 (54.3)	2.59	2.07–3.24
≥15 years	1,222	896 (73.3)	2.26	1.96–2.61

* MCL = midclavicular line; PE = physical examination; MSL = midsternal line.

matobia. However, there was no relationship between the prevalence of PPF in communities and the community burden of *S. haematobium* infection in the other schistosomiasis haematobia-endemic governorates.

Schistosomiasis mansoni. The prevalence of *S. mansoni* in the 5 governorates where it was endemic averaged 36.4% and ranged from 17.5% in Qalubia to 42.9% in Ismailia (Table 1). The average intensity of infection was a GMEC of 81.3 eggs/g of stool and ranged from 62.6 in Qalubia to 93.3 in Ismailia. Age-adjusted prevalence of infection peaked at 48.3% in the 15–19-year-old group, but was very high (in the 35–45% range) from the 10–14-year-old age group onward (Figure 2). All older age groups were at least twice as likely (ORs = 2.0–3.3) to have *S. mansoni* infections as the group <10 years of age (Table 4). Males had a higher prevalence of infection than females in all age groups (Figure 2), and were 1.6 times as likely to be infected than females (Table 4); 41.0% of the males had *S. mansoni* ova in their stools compared with 31.4% of the females. The intensity of infection was highest, with a GMEC of 94.7 ova/g of stool, in the 10–14-year-old age group but it remained in the 70–85 range in all groups more than 5 years of age. Those living in ezbas were more likely (OR = 1.9) to be infected than subjects living in larger communities. A history of any of several types of exposures to canal water increased the ORs (2.3–2.8) of having an *S. mansoni* infection. Other risk factors significantly associated with *S. mansoni* infection were history of (OR = 1.6), or treatment for (OR = 1.5), schistosomiasis and a recent history of blood in the stool (OR = 2.3), particularly in children (OR = 3.1).

Infection with *S. mansoni* was not associated (OR = 1.0) with abdominal pain (Table 4). However, subjects, particularly children, with *S. mansoni* infections were slightly more likely to have hepatomegaly detected by physical examination (OR = 1.2) and slightly more than 50% had splenomegaly (OR = 1.6). Ultrasonography-detected hepatomegaly in the MCL was detected in 22.3% of the 6,850 subjects; left hepatic lobe enlargement was detected less frequently (735 [10.7%] of 6,847). Splenic enlargement was observed in 1,453 (20.8%) of the 6,970 having this evaluated by ultrasonography. Periportal fibrosis was present in 3,494 (50.3%) of the 6,941 subjects examined; 378 (5.4%) had grade II changes while 85 (1.2%) had the more advanced grade III changes. Infection with *S. mansoni* was slightly more likely (OR = 1.4) to be present in subjects with PPF than in those without PPF. The ORs increased with increasing grade of PPF (Table 4).

Hepatic morbidity, defined as ultrasonography-detected PPF, was present in about half of the 7,684 evaluated for morbidity (Table 5). Risk factors for morbidity included increasing age (OR = 2.9–4.2), male gender (OR = 1.6), males bathing in canal water (OR = 1.9), females washing dishes or clothing in canal water (OR = 2.1), and children swimming or playing in canal water (OR = 1.6) in canal water, *S. mansoni* ova in the stool (OR = 1.4), a history of (OR = 2.2), or treatment for (OR = 2.2), schistosomiasis; and a history of blood in the stool (OR = 1.4). Unlike the case in schistosomiasis haematobia-endemic areas, living in smaller satellite communities was not a risk (OR = 0.9) for morbidity.

A history of abdominal pain did not correlate (OR = 1.0) with hepatic morbidity. Periportal fibrosis was less frequent (OR = 0.7) in subjects with hepatomegaly detected by physical examination in comparison with those without this (Table 5). However, splenomegaly detected by physical examination was associated (OR = 2.5) with PPF, at least in adults (OR = 2.2). Ultrasonography confirmed the physical examination results: PPF was less common (ORs = 0.6 and 0.7) in those with hepatomegaly in the MCL or MSL in comparison with subjects without these findings, and PPF was present almost 3 times as frequently (OR = 2.82) in subjects having enlarged spleens.

Right hepatic lobe enlargement had a marginal negative correlation with the community burden of schistosomiasis mansoni in 2 (Menofia [$r = -0.46$, $P = 0.01$] and Kafr El Sheikh [$r = -0.40$, $P = 0.06$]) of the 5 schistosomiasis mansoni-endemic governorates. Splenomegaly correlated with the community burden of schistosomiasis mansoni in 3 (Is-

mailia [r = 0.29, $P = 0.04$], Menofia [r = 0.50, $P = 0.01$], and Kafr El Sheikh [r = 0.44, $P = 0.03$]) of the 5 governorates. Periportal fibrosis had a marginally positive association (r = 0.41, $P = 0.04$) with the community burden of schistosomiasis mansoni only in Qalubyia among the *S. mansoni*-endemic governorates.

DISCUSSION

In 1935, Azim reviewed the early 20th century epidemiologic studies of schistosomiasis in Egypt.[19] He noted that *S. haematobium* was the only species present in Upper Egypt and that *S. haematobium* was more prevalent in Lower Egypt than *S. mansoni*.

The first country-wide survey was published by Scott in 1937.[6] He reported the results of parasitologic examinations performed on 2 million patients seen between 1932 and 1934 in government treatment centers dispersed throughout rural areas in the country, and on results of examinations of specimens collected from 40,000 subjects during house-to-house surveys. The subjects in this survey were not randomly selected; instead Scott selected the communities to be representative of the districts where the screening was performed. The distribution and prevalence of infection in the country was carefully described for the first time. North and east of the delta, 60% of the rural population were infected with *S. haematobium* and about the same proportion was infected with *S. mansoni*. In the southcentral part of the delta, the prevalence of *S. haematobium* remained at 60%, but only 6% had schistosomiasis mansoni. *Schistosoma mansoni* was not prevalent south of Cairo in Upper Egypt. In districts in Upper Egypt under perennial irrigation, infection rates with *S. haematobium* were also about 60%. In the areas under basin irrigation, only about 5% were infected. Perennial irrigation extended up the Nile River to near Luxor.

Later studies based upon data from the Ministry of Health's treatment centers for schistosomiasis and hookworm confirmed and extended Scott's findings.[20,21] Miller and others reported parasitologic results from specimens obtained from a stratified random sample of 11,337 subjects in 1976 that was fairly evenly divided between Kafr El Sheikh in Lower Egypt, Beni Suef in Middle Egypt, and Aswan in Upper Egypt.[22] All urine specimens were examined in the rural health units using the sedimentation technique. The stools were coded and preserved and later examined in the parasitology department of the High Institute of Public Health in Alexandria using the methiolate-iodine-formalin concentration procedure. The prevalence of *S. haematobium* infections in the 3 areas was 30% in Kafr El Sheikh, 27% in Beni Suef, and 4% in Aswan in villages built in the desert and 25% in villages constructed within or near cultivated fields. *Schistosoma mansoni* infection rates averaged 20% in Kafr El Sheikh, but <1% were infected with this species in Middle and Upper Egypt. An increased risk for infection in males versus females was noted with a gradation from Upper Egypt (4.0-fold), to Middle Egypt (2.1-fold), to the Nile delta sites (1.4-fold). Homes that had piped water had lower infection rates that those that used public faucets, which in turn, had lower infection rates than households obtaining their water supply from canals.

Following construction of the Aswan High Dam in the 1960s, changes in distribution of *Schistosoma* infections gradually took place. Decreases in prevalence of human *S. haematobium* infections in conjunction with increases in *S. mansoni* and a replacement of the reservoir of the former, *Bulinus truncatus*, with the reservoir of the later, *Biomphalaria alexandrina*, were reported.[3–5] Our results confirm that *S. mansoni* has almost completely replaced *S. haematobium* in Lower Egypt and that it is spreading into Upper Egypt, where focal areas of transmission are occurring.

Risk factors for active *S. haematobium* and *S. mansoni* infections were similar to each other and to what has been described in prior investigations based upon less extensive data: an age between 5 and 20 years old, male gender, a history of exposure to canal water, a history of, or treatment for, schistosomiasis, and living in smaller communities. The latter risk is probably related to a lower socioeconomic status among those who live in ezbas, who are more likely to be employed in agriculture and have less convenient access to medical care (and treatment for schistosomiasis) since the rural health centers are placed in the larger villages. The other risk factors are all related to exposures to infection: children, males, and those previously infected are all more likely to have more exposure to infectious canal water than those not belonging to these groups. Some risk factors confound each other and their actual contribution cannot be reliably estimated without performing multivariant analysis, a statistical method too complicated to use during the first descriptive presentation of the data.

A history of burning micturition or hematuria correlated with active *S. haematobium* infections, and a history of blood in the stool was a risk factor for active *S. mansoni* infection. Documentation of hematuria and proteinuria using reagent strips also improved the chances of having schistosomiasis haematobia. However, this is evaluated in much more detail in a report of the data from Minya.[23] Stratification by gender and age is required for optimal use of these markers for predicting *S. haematobium* infection.

There was an association between urinary bladder and urinary tract obstructive lesions and the size of the community in Upper Egypt: those living in ezbas were more at risk for infection than those living in larger communities. This may be due to 1) shop keepers, school teachers, commuting factory workers, and others who do less agriculture work and have less exposure to infection usually live in larger communities; 2) those living in the larger communities are usually better educated, and would be more likely to avoid exposures to infectious water than those living in ezbas; and 3) ezbas have less facilities, e.g., piped water supplies, sewage disposal, electricity, than the villages, which increase exposures to infection. This association of prevalence of infection with the populations' intensity of exposure has been well documented.[24] The present investigation documented that a history of 3 different types of increased exposure to canal water increased frequency of *S. mansoni* infection by 2- or 3-fold. Since females do not frequently bath in canals, males seldom wash dishes or clothing in canals, and children are more likely than adults to play or swim in the water, these variables were stratified into the appropriate age and gender groups. When the data is not stratified in this manner prior to analysis, the results are meaningless. The higher prevalence of infection in males than in females in all age

groups could also be explained by their greater exposure to canal water while farming.[24]

Acknowledgments: The data was managed by the Core Team under the supervision of Dr. Mohamed H. Hussein (Kasr El-Aini Faculty of Medicine), who also advised Dr. Nabiel N. H. Mikhail (Assiut Faculty of Medicine), who performed the data analysis. We also thank the many members of each of the teams who performed these studies, and the members of the surveyed communities and employees of the Ministry of Health rural health centers who helped with the collection of data.

Financial support: This research was supported by the Egyptian Ministry of Health/USAID-funded Schistosomiasis Research Project, 263-0140.2, grants no. 02.04.17,18,19,20,21,22,23,24 and 10-04-83.

Authors' addresses: Taha El-Khoby, Nabil Galal, and Alan Fenwick, Schistosomiasis Research Project, The Egyptian Organization for Biological and Vaccine Production, 51 Wezarat El Zerra Street, Agouza, Egypt. Rashida Barakat (Kafr El Sheik), Department of Parasitology, High Institute of Public Health, Alexandria, Egypt. Anwar El Hawy (Gharbiya), Department of Tropical Medicine, Faculty of Medicine, Al Azhar University, Cairo, Egypt. Zoheir Nooman (Ismailia), Faculty of Medicine, Suez Canal University, Ismailia, Egypt. Mustafa Habib (Qaluybia), Center for Field and Applied Research, Warac, Egypt. Farid Abdel-Wahab (Menoufia and Fayoum), Department of Tropical Medicine, Faculty of Medicine, University of Cairo, Cairo, Egypt. Nabil S. Gabr (Minya), Department of Parasitology, Faculty of Medicine, Minya University, Minya, Egypt. Hammam M. Hammam (Assiut and Qena) and Nabiel N. H. Mikhail, Department of Community Medicine, Faculty of Medicine, Assiut University, Assiut, Egypt. Mohamed H. Hussein, Department of Community Medicine, Faculty of Medicine, University of Cairo, Cairo, Egypt. Barnett L. Cline, PO Box 1477, Blanco, TX 78606. G. Thomas Strickland, International Health Program, Department of Epidemiology and Preventive Medicine, School of Medicine, University of Maryland at Baltimore, Baltimore, MD 21201.

Reprint requests: Schistosomiasis Research Project, Medical Services Corporation International, 1716 Wilson Boulevard, Arlington, VA 22209.

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